Design of Nano-Structures for Energy Efficient Devices

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Abstract

Thermoelectric materials are increasingly becoming more important due to their applications in thermoelectric power generation as heat harvesting and microelectronic cooling devices [1, 2]. The theory of thermoelectric power generation and thermoelectric refrigeration was first presented by Altenkirch in 1990 [3]. The efficiency of the thermoelectric devices and materials is determined by the figure of merit [4] $ZT = S^2\sigma T / \kappa$ where S is the Seebeck coefficient, σ is the electrical conductivity, T is the absolute temperature, and κ is the thermal conductivity [5, 6]. Effective thermoelectric materials and devices have a low thermal conductivity and a high electrical conductivity [7]. Solid state thermoelectric devices are reliable energy converters since they do not have noise or vibration due to not having mechanical moving parts [8]. Therefore, thermoelectric materials (TEM) are attracting worldwide attention now, for use of exhaust waste heat from power plant or automobile [9]. Recent years witnessed remarkable growing interest in thermoelectric nano-composite for energy conversion applications [10]. We have been working on over 20 different nanostructured thermoelectric thin film systems. The thin film systems have been prepared using high vacuum deposition techniques like DC/RF Magnetron sputtering and Ion Beam Assisted Deposition. In order to form nano-structures (nano dots and / or nano clusters) in the multilayers, we used thermal annealing and MeV Si ion bombardments performed with the Pelletron ion beam accelerator at the Alabama A&M University Materials Research Laboratory (AAMU-MRL). The prepared multi-nano-layered thin film systems were characterized using Seebeck coefficient, van der Pauw electrical resistivity, thermal conductivity, SEM+EDS, AFM, Raman, Optical absorption, XPS, RBS measurement techniques. The findings from some of the ongoing researches in AAMU will be presented.

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